

*BY ORDER OF THE COMMANDER*

SMC Standard SMC-S-020

3 June 2009



-----  
Supersedes:  
New issue

Air Force Space Command

**SPACE AND MISSILE SYSTEMS CENTER  
STANDARD**

**TECHNICAL  
REQUIREMENTS FOR  
WIRING HARNESS,  
SPACE VEHICLE**

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

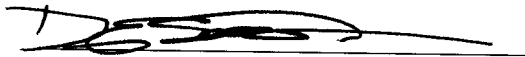


## FOREWORD

1. This standard defines the Government's requirements and expectations for contractor performance in defense system acquisitions and technology developments.
2. This new-issue SMC standard comprises the text of The Aerospace Corporation report number TOR-2008(8383)-8492, entitled *Technical Requirements for Wiring Harness, Space Vehicle, Design and Testing, General Specification for*.
3. Beneficial comments (recommendations, changes, additions, deletions, etc.) and any pertinent data that may be of use in improving this standard should be forwarded to the following addressee using the Standardization Document Improvement Proposal appearing at the end of this document or by letter:

Division Chief, SMC/EAE  
SPACE AND MISSILE SYSTEMS CENTER  
Air Force Space Command  
483 N. Aviation Blvd.  
El Segundo, CA 90245

4. This standard has been approved for use on all Space and Missile Systems Center/Air Force Program Executive Office - Space development, acquisition, and sustainment contracts.

  
DAVID E. SWANSON, COL, USAF  
SMC Chief Engineer



## Contents

1.	SCOPE.....	1
	1.1 Purpose.....	1
	1.2 Application.....	1
	1.3 Compliance with System Requirements.....	1
2.	APPLICABLE DOCUMENTS .....	3
	2.1 Military Specifications.....	3
	2.2 Military Standards .....	3
	2.3 Military Handbooks.....	3
	2.4 Other Publications. ....	4
3.	REQUIREMENTS .....	5
	3.1 Order of Precedence.....	5
	3.2 Supplementary Specifications and Standards.....	5
	3.3 Selection of Parts, Materials and Processes .....	5
	3.4 General Design Requirements.....	5
	3.4.1 Circuit Categories.....	5
	3.4.2 Shielding requirements.....	7
	3.4.3 Shield Termination and Shield Grounding.....	8
	3.4.4 Wire Terminations.....	9
	3.4.5 Circuit Isolation.....	9
	3.4.6 Mockup.....	9
	3.4.7 Routing.....	9
	3.4.8 Protection and Support.....	10
	3.5 Wire and Cable Requirements .....	10
	3.6 Connector Requirements.....	11
	3.7 Assembly and Fabrication Requirements.....	11
	3.7.1 Fabrication Forming Board .....	11
	3.7.2 Wire Lay.....	11
	3.7.3 Other Requirements.....	11
	3.8 Harness Identification and Data Requirements.....	12
	3.8.1 Wiring Data .....	12
	3.8.2 Identification of Individual Conductors .....	12
	3.8.3 Identification of Harnesses .....	12
	3.9 Operability .....	12
	3.9.1 Reliability .....	12
	3.9.2 Interchangeability.....	12
	3.9.3 Maintainability .....	12
	3.9.4 Service Life .....	12
	3.9.5 Environment .....	13
	3.9.6 Storage and Transportability .....	13
	3.9.7 Workmanship. ....	13
4.	Quality Assurance Requirements .....	15
	4.1 Responsibility for Inspections and Tests .....	15

4.2	Classification of Inspections and Tests.....	15
4.2	Parts, Materials, and Process Controls.....	15
4.4	Physical Configuration Audit .....	15
4.5	Acceptance testing .....	15
4.5.1	Contact Retention Test.....	15
4.5.2	Circuit Resistance Test.....	16
4.5.3	Insulation Resistance Test.....	16
4.5.4	High Potential Withstanding Test.....	16
4.5.5	Insulation Resistance Retest.....	17
4.5.6	Contact Separation Force Test .....	17
4.5.7	Environmental Testing .....	17
4.5.8	Acceptance Criteria.....	17
4.6	Qualification .....	18
4.7	Modifications, Rework, and Retesting .....	18
5.	Packaging (Not Applicable).....	19
6.	Notes .....	21
6.1	Tailored Application.....	21
6.2	Definitions .....	21
6.2.1	Wire .....	21
6.2.2	Shield.....	21
6.2.3	Cable .....	21
6.2.4	Cable Assembly .....	21
6.2.5	Wiring Harness .....	22
6.3	Supersession Data.....	22

## Tables

Table 1.	Summary of Circuit Categories and Shielding Requirements .....	6
Table 2.	Contact Separating Forces Requirements .....	17

## **1. Scope**

### **1.1 Purpose**

These requirements set forth the general design and testing requirements for electrical wiring harnesses (see 6.1) and cable assemblies (see 6.2.4) that are to be installed in space vehicles.

### **1.2 Application**

The wiring requirements covered by this document are applicable to wiring harnesses and accessories for the use in the interconnection of electrical and electronic equipment in space vehicles. These requirements may also be used to specify requirements for interconnect wiring on launch vehicles, intercontinental ballistic missiles, or other vehicles (see 6.1). For those applications the term “space vehicle” is to be interpreted as the applicable vehicle. This document may be tailored by the acquisition activity for the specific application or program prior to contract award.

### **1.3 Compliance with System Requirements**

These requirements shall not relieve the contractor and subcontractors of the responsibility for complying with all the equipment, system performance, and reliability requirements as set forth in the applicable specifications and contract.





## 2. Applicable Documents

The following documents form a part of these requirements to the extent as specified herein.

### 2.1 Military Specifications

MIL-DTL-17H	Cables, Radio Frequency, Flexible and Semi-rigid, General Specification for
MIL-DTL-5846D	Chromel and Alumel Thermocouple Electrical Wire, Detail Specification for
MIL-DTL-24308F	Connectors, Electrical, Rectangular, Non-environmental, Miniature, Polarized Shell, Rack and Panel, General Specification for
MIL-DTL-38999L	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect, (Bayonet, Threaded, and Breech Coupling), Environmental Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for
MIL-PRF-39012E	Connectors, Coaxial, Radio Frequency, General Specification for
MIL-DTL-81381C	Wire, Electric, Polyimide-Insulated, Copper or Copper Alloy, General Specification for
MIL-DTL-83723F	Connectors, Electrical, (Circular, Environment Resisting), Receptacles and Plugs, General Specification for
MIL-DTL-83733E	Connectors, Electrical, Miniature, Rectangular Type Rack to Panel, Environment Resisting, 200 Degrees C Total Continuous Operating Temperature, General Specification for
MIL-W-81044	Wire, Electric, Crosslinked Polyalkene, Crosslinked Alkane-imide Polymer, or Polyarylene Insulated, Cooper or Cooper Alloy
MIL-W-83575A	Military Specification Wiring Harness, Space Vehicle, Design and Testing, General Specifications for – This is superceded by DOD-W-83575A (USAF)
MIL-W-22579	Replaced by SAE is preferred type.

### 2.2 Military Standards

None

### 2.3 Military Handbooks

MIL-HDBK-216	R. F. Transmission Lines and Fittings; cancelled 8 Sept 2001; no replacement
MIL-HDBK-863	Handbook for Wiring Data and System Schematic Diagrams Preparation of

## 2.4 Other Publications

The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issue in effect on date of bids or request for proposal shall apply.

The Institute of Electrical and Electronics Engineers:  
IEEE 200-1975 Reference Designation for Electrical and Electronics Parts and Equipments (with ANSI Y32. 16-1975)

Application for copies should be addressed to:  
Institute of Electrical and Electronics  
Engineers, Inc. 345 East 47<sup>th</sup> Street  
New York, New York 10017

The Aerospace Corporation Publications:

1. TOR-2006(8583)-5235 Parts, Materials, and Processes Control Program for Space and Launch Vehicles.
2. TOR-2006(8583)5236 Technical Requirements for Electronic Parts, Materials, and Processes Used in Space and Launch Vehicles.

Application for copies of the Aerospace TOR documents should be addressed to:  
Charles C. Lauritsen  
Library c/o The Aerospace Corporation  
2350 East El Segundo Bl.  
El Segundo, CA 90245-4691

Society of Automotive Engineers:

1. AS50881 Rev. C. Wiring Aerospace Vehicles

Application for copies of SAE publications should be addressed to:  
SAE International  
400 Commonwealth Drive  
Warrendale, Pennsylvania 15096-0001

NOTE:

All reference in this document to Aerospace Report number TOR-2006(8583)-5235 shall refer to SMC Standard SMC-S-009 (2009).

All reference in this document to Aerospace Report number TOR-2006(8583)-5236 shall refer to SMC Standard SMC-S-010 (2009).

### **3. Requirements**

#### **3.1 Order of Precedence**

In the event of conflicts between any of the documents referenced herein and the contents of this reference, the contents of this reference shall be considered the superseding requirements.

#### **3.2 Supplementary Specifications and Standards**

When these references herein fail to provide a suitable specification or standard, other specifications or standards may be used. If the referenced documents do not provide the contractually required reliability, quality level, or technical performance, they should be interpreted as limiting the physical and functional parameters. In those cases, the specifications should be the basis of contractor specifications that would add, delete, or change specific requirements. When a detail or general military specification exists for the class of material required, the contractor's specification shall reference the existing military specifications and set forth only the new requirements and deviations. If required by the contract, the supplementary specifications that are prepared by the contractor shall be submitted to the contracting officer for review or approval prior to their use. When required by the contracting officer, the contractor shall provide data substantiating the supplementary requirements and shall provide samples for testing. The use of the contractor's specifications shall not constitute waiver of Government inspection requirements.

#### **3.3 Selection of Parts, Materials and Processes**

Unless otherwise specified in the contract the parts, materials, and processes shall be selected and controlled in accordance with Section 4 "General Requirements" of TOR-2006(8583)-5235. The contractor's established and documented procedures are to comply with these General Requirements. The selection and control procedures shall emphasize quality and reliability, as required, to minimize total life cycle costs for the applicable vehicles. An additional objective in the selection of parts shall be to maximize commonality and minimize the variety of wiring components and related servicing tools required in the fabrication, installation and maintenance of the vehicle electrical wiring system.

#### **3.4 General Design Requirements**

##### **3.4.1 Circuit Categories**

The electrical characteristics required for interconnecting wiring are the first considerations to be established in designing electrical wiring harness for space vehicles. In particular, the wire types (see 6.2.1) required depends upon the voltage, current capacity, and frequency of the circuits. The five major categories and the various subcategories of circuits are defined in the following subparagraphs and summarized in Table 1. Each circuit in each wiring harness or cable assembly shall be categorized in accordance with these definitions.

Table 1. Summary of Circuit Categories and Shielding Requirements

Circuit Character	Level Volts (V) or Amperes (A)	Category (see 3.4.1)	Shielding (see.4.2)
Direct current	Below 10 V and less than 5 A	IIIa	Shielded as a group from other categories
	Below 10 V and above 5A	Ib	None
	Above 10 V	Ia	None
Alternating current Below 0.1 MHz	Below 5V RMS	IIIc	Shielded as a group from other categories
	Between 5V and 25 V RMS	IIc	Each pair shielded
	Above 25 V RMS	Ic	None
Alternating current Between 0.1 MHz and 1 MHz	Below 1 V RMS	IIIb	Each pair shielded
	Between 1 V and 10 V RMS	IIId	Each pair shielded
	Above 10 V RMS	Vc	Coax or balanced shielded cable
Alternating current above 1 MHz	All	Va	Wave guide, coax, or balanced shielded cable
Pulse with rise or fall time greater than 1 microsecond	Below 5 V peak	IIIe	Each pair shielded
	Between 5V and 25V peak	IIa	Each pair shielded
	Above 25V peak	Id	None
Pulse with rise or fall time less than 1 microsecond	Below 1 V peak	IIIId	Each pair shielded
	Between 1 V and 10 V peak	IIb	Each pair shielded
	Above 10 V peak	Vb	Coax or balanced shielded cable
Electro explosive (EED)	All	IV	Each pair shielded

### 3.4.1.1 Category I (Power and Control)

Includes (a) DC circuits over 10 V, (b) DC circuits below 10 V and over 5 A, (c) AC circuits below 0.1 MHz with voltages above 25 V rms, and (d) pulse circuits with maximum voltages above 25 Volts with rise and fall times greater than 1 microsecond.

### 3.4.1.2 Category II (High Level Signals)

Includes (a) digital circuits with voltage levels from 5 to 25 V maximum and rise and fall times greater than 1 microsecond, (b) digital circuits with maximum voltage levels from 1 to 10 Volts and rise and fall times less than 1 microsecond, (c) AC circuits below 0.1 MHz with voltages between 5 V and 25 V, and (d) AC circuits between 0.1 MHz and 1.0 MHz with voltage levels between 1 V to 10 V and rise or fall times less than 1 microsecond, (c) AC circuits below 0.1 MHz with voltages between 5 V and 25 V, and (d) AC circuits between 0.1 MHz and 1.0 MHz with voltage levels between 1 V and 10 V.

### 3.4.1.3 Category III (Low-Level Signals)

Includes (a) DC circuits below 10 V and less than 5A, (b) AC circuits between 0.1 MHz and 1.0 MHz with voltage levels less than 1 V, (c) AC circuits below 0.1 MHz with voltages less than 5 V, (d)

digital circuits with maximum voltages less than 1 V with rise times less than 1 microsecond, and (e) digital circuits with maximum voltages less than 5 V and rise and fall times greater than 1 microsecond.

#### **3.4.1.4 Category IV (Electro Explosive Device Circuits)**

Includes all electro explosive device (EED) circuits.

#### **3.4.1.5 Category V (High-Frequency Signals)**

Includes (a) all AC circuits above 1 MHz and (b) high level digital circuits with maximum voltages above 10 V and with rise or fall times less than 1 microsecond, and (c) AC circuits between 0.1 MHz and 1.0 MHz with voltages levels above 10 V.

### **3.4.2 Shielding requirements**

Shielding (see 6.2.2) shall be provided as indicated in the following subparagraphs. All shielding shall be insulated to prevent uncontrolled grounding.

#### **3.4.2.1 Interconnect Wiring for Category I Circuits**

Wiring for category I circuits shall have the power or signal wire(s) twisted with the return wire. The wiring may be unshielded.

#### **3.4.2.2 Interconnect wiring for category II Circuits**

Wiring for category II circuits shall have twisted signal and return wires with each pair, or circuit, shielded.

#### **3.4.2.3 Interconnect Wiring for Category III circuits**

Wiring for category IIIa shall have twisted signal and return wires. Category IIIa wiring shall be shielded as a group from category IIIb and other categories. Wiring for category IIIb shall have twisted signal and return wires with each pair, or circuit, shielded. Wiring for category IIIc shall have twisted signal and return wires. Category IIIc wiring shall be shielded as a group from category IIIa, IIIb, and other categories. Wiring for category IIId and category IIIe shall have twisted signal and return wires with each pair, or circuit, shielded.

#### **3.4.2.4 Interconnect wiring for Category IV Circuits**

Wiring shall be twisted pairs, each pair shielded.

#### **3.4.2.5 Interconnect Wiring for Category V circuits**

Wiring interconnections, other than waveguide, shall be shielded coaxial cable, balanced shielded cable, or balanced cabled with a characteristic impedance of 100 ohms or less.

#### **3.4.2.6 Added Shielding**

Shielding can be added over that specified for the category of each circuit to prevent excessive radiation from, or excessive pickup on, the circuit. Coax or balanced shielded cable may be used instead of twisted shielded pairs particularly in applications where the capacitance per meter is critical. Shielding shall be added over that specified for the category of each to the extent required

when an electromagnetic pulse (EMP) environment is specified. Shielded circuits may be routed together in a bundle with a common secondary shield.

### **3.4.3 Shield Termination and Shield Grounding**

Multiple point shield grounding shall be used on high-frequency circuits (above 0.1 MHz), on digital circuits with rise or fall times less than 1 microseconds, and on all EED firing circuits (category IV). Single and shield grounding shall be maintained on all other circuits, except that when multiple shields are used to prevent induced interference, the outer shield shall be multipoint grounded. When single and shield grounding is used to protect a circuit against induced radiation, the ground shall be at the receiver or high impedance end. When single and shield grounding is used to minimize radiation from a circuit, the ground shall be at the signal source end.

#### **3.4.3.1 Shield Terminations for Electromagnetic Pulse (EMP)**

Wire shields in all categories shall be bonded around the circumference, and preferably within the backshell of the connectors. Inner shields that are designed to be ungrounded at one end shall be terminated within the connector shell and the ends secured against fraying. Ungrounded inner shield terminations shall be insulated from the connector pins, the backshell of the connector, and from adjacent shields.

#### **3.4.3.2 Shield ground Terminations for Category IV circuits**

Wire shields in category IV circuits (EEDS) shall be bonded around the circumference, and preferably within the backshell of the connectors. Circuits such as pyrotechnic event instrumentation circuits that make a direct connection to the electro explosive device circuit shall employ shields which are bonded around the circumference and preferably with the backshell at the pyro junction or relay box connector. If an EMP environment is not specified, the shield ground at the other instrumentation circuit connector may be grounded through a pigtail to a pin in the connector or directly to the structure.

#### **3.4.3.3 Shield Ground Terminations for category I, II, III, and V Circuits (no EMP)**

Wire shields in these categories of circuits that require grounding and are not subjected to an EMP environment, shall be grounded to the vehicle structure by the shortest feasible route. The length of the pigtail or connection wire between the shield and the ground shall be as short as practicable, but shall not exceed 100 millimeters (mm) for harnesses containing less than 20 shielded wires. The length of unshielded, insulated wire that may show in back to the connector shell shall be as short as practicable, but shall not exceed 20 mm. For these circuits, the following methods of grounding the shields are acceptable, in order of preference:

- a. On, and preferably within, the electrical connector to provide a low impedance path to structure when joined to the mating connector.
- b. By a pigtail to a pin in the electrical connector.
- c. By a pigtail directly to structure.

#### **3.4.3.4 Ungrounded Shield Terminations (no EMP)**

Wire shield terminations that are to be ungrounded, and are not subjected to an EMP environment, shall be secured against fraying and insulated from the back shell of the connector and from adjacent

shields. Where practicable, the ungrounded end of the shield should be terminated by a pigtail to a connector pin to facilitate making shield continuity and resistance measurements (see 4.5.2). The length of unshielded, insulated wire that may show in back of the connector shell shall be as short as practicable but shall not exceed 20 mm.

#### **3.4.4 Wire Terminations**

Wire terminations to connectors or terminal shall be made with a crimp device where practicable. Wires to be terminated shall be stripped of insulation by methods that do not result in nicked or broken strands. The length of the stripped portion of the conductor shall be long enough to reach the bottom of the crimp barrel. Not more than one wire (conductor) shall be terminated to any contact of environmentally sealed connectors. Not more than one wire (conductor) shall be terminated in an individual terminal lug. For screw type terminal boards, the harness design shall be such that the maximum number of lugs to be connected to any one terminal on a terminal board shall be four for ring type lugs, or two for spade type lugs.

#### **3.4.5 Circuit Isolation**

Interconnect wiring in each of the five categories shall be isolated from wiring in other categories by maintaining, to the extent practicable, a minimum separation of 30 mm between wires and wire bundles of the different categories. When wires from circuits in different categories use the same connector, the pin assignments and layout shall stress isolation between different categories, and grounded spare pins shall be fully utilized to provide such isolation. Category IV circuits (electro plosive devices) shall maintain a minimum distance of 30 mm from other category circuits and shall not share the same connector with other category circuits. High impedance circuits above 1000 ohms, or sensitive circuits, below 5 V, shall be isolated by routing or shielding or both from other circuits even in the same category. Antenna cables shall be separated from each other and from other wiring. Where practicable, wiring to redundant subsystems or equipment shall be run in separate harnesses or cable assemblies to prevent damage to one subsystem affecting the other.

#### **3.4.6 Mockup**

A three-dimensional mockup of the space vehicle shall be provided where required to determine the proper routing, wire lengths, connector configurations, support requirements, and access requirements of the wiring harnesses. The mockup may be limited to partial installations which contain the more complex wiring harnesses. The mockup shall be used to support design reviews of the wiring harnesses, to fabricate wire jig boards, to demonstrate typical installations, and to show all wiring practices for which deviations are requested. A development test vehicle, a qualification test vehicle, or a flight vehicle may be used for harness mockups instead of creating a separate vehicle mockup if adequate time is scheduled to support the wiring harness mockup activities.

#### **3.4.7 Routing**

System reliability shall be a primary consideration in selecting the routing for wiring harnesses or cable assemblies. Where practicable, routing shall provide accessibility for easy removal and replacement of attached equipment as well as the wire harness. Routing through small structural openings shall be avoided where practicable to minimize flexing and handling of the harness during its installation.

The allowable cable size and minimum radius of bends shall be in accordance with SAE AS50881 paragraph 3.11.7. Routing shall be such as to minimize the possibility of damage to the wiring. Interference with other equipments shall be avoided. Routing shall offer protection against possible

damage through common misuses such as being a handhold or temporary support for test equipment. Although similar connectors or cable terminations should not be used in adjacent locations, the routing and forming shall be such that improper connections cannot be made.

To prevent possible damage from fumes and fluids, a 50-mm minimum clearance shall be maintained, where practicable, between the harnesses and lines or equipment containing oxygen, flammable liquids or gases, corrosive liquids or gases, or cryogenic liquids or gases.

The clearance between wires or cables and heat generating devices shall be such as to avoid deterioration of wires or cable from the heat dissipated by the devices in accordance with SAE AS 50881 paragraph 3.10.16.

Routing shall provide slack to prevent mechanical strain on the wire, junctions, and supports resulting from installation and servicing of equipment, vibration, thermal environments, and tolerance build up including vehicle and harness fabrication. Additional slack shall be provided in the area of terminations to allow the replacement of terminations three times; however, excessive slack shall not be provided. Wire bundles crossing a moving or rotating interface shall not contain strain-energy elements to assist deployment.

Where wiring harnesses must cross a moving or rotating interface, such as a deployable solar array attach fitting, the installation drawings shall define dimensions including loop sizes and distances to attachments in accordance with SAE AS50881 paragraph 3.11.9. Attachment clamps shall be provided sufficiently close to any loops so that movement into the path of motion of the moving mechanical assembly cannot occur under any conditions. Connectors shall be provided at each end of the loop where practicable to permit assembly and disassembly without disturbing the harness configuration in the area of the interface.

### **3.4.8 Protection and Support**

Wiring harnesses and cable assemblies shall be protected and supported in accordance with SAE AS50881 paragraph 3.11.1. Harness breakouts shall be supported to avoid overstressing of the wires by flexing of the breakout. Accessories such as sleeving, grommets, insulation tape, clamps, straps, tying tape, and other related items, shall be in accordance with SAE AS50881 paragraph 3.11.6. Unmated connectors shall be provided with dust caps to prevent damage to the pins and the entry of foreign matter in accordance with SAE AS50881 paragraph 3.14.11.

### **3.5 Wire and Cable Requirements**

The type of wire shall be in accordance with TOR-2006(8583)-5236; Section 1500 (wire and cable) paragraphs 4.1 through 4.7.

Thermocouple applications may use MIL-DTL-5846D (Detail Specification Chromel and Alumel Thermocouple Electric Wire) type wires.

Coaxial cable shall be in accordance with MIL-DTL-17H. MIL-HDBK-216 shall be used as a guide for the selection of coaxial cable.

The selection of wire size shall be based upon circuit current and cable size in accordance with the requirements of SAE AS50881 paragraph 3.8.8.1. or thermal math model. The minimum wire gauge used is #22 AWG; annealed copper and 24 AWG high strength copper alloy shall be restricted in accordance with SAE AS50881 paragraph 3.8.8.



The wire temperature ratings are short term ratings. Operating wire in excess of 50 percent of rated temperature requires engineering evaluation.

### **3.6 Connector Requirements**

Connectors used in the fabrication of wire harnesses and cable assemblies shall be suitable for the application. Wire harness connectors shall be of the rear insertable removable crimp contact and quick disconnect type where feasible. Except as modified herein, connectors shall be in accordance with TOR-2006(8583)-5236; Section 300, Connectors, and SMC-S-009; Section 300, Connectors. Similar connectors located in the same physical area of the space vehicle shall have different keying arrangements to preclude connector mismatching (reference harness routing and forming restrictions in 3.4.7). Connectors to be used in an EMP or High level RF environment shall be capable of incorporating RF finger stock at the connector-receptacle interface to provide for shield continuity and shall be mechanically capable of being subjected to the coupling nut torque. Connectors that are not self-locking shall be safety wired.

### **3.7 Assembly and Fabrication Requirements**

#### **3.7.1 Fabrication Forming Board**

Fabrication of all wire harnesses or cables assemblies for space vehicles shall be on a three dimensional jig, or on a fabrication forming board that reproduces the size and shape of the harness when installed in the vehicle. All electrical terminations shall be located with position, tilt, and index identical to the final vehicle installation. Connector shells with inserts shall be used to reproduce the mating interface and facilitate testing. When desired by the contractor, the vehicle itself may be used as the jig to fabricate the harness in place.

#### **3.7.2 Wire Lay**

##### **3.7.2.1 Twisted or Helical Wire Lay**

Wiring harnesses or cable assemblies consisting of more than four conductors that terminate in connectors, and that are subjected to flexing when mated and demated, shall be fabricated with a twisted or helical wire lay for that portion of the wire harness or cable assembly that is subject to movement during the connector mating or demating operations.

##### **3.7.2.2 Parallel or Straight Wire Lay**

A wiring harness or cable assembly may be fabricated with a parallel or straight wire lay for that portion of the wiring harness or cable assembly which is permanently installed in the spacecraft, and which is not subject to movement after installation.

#### **3.7.3 Other Requirements**

Splices are prohibited except where the use of a connector is practicable or would reduce reliability. For example, splices may be used when wiring can be permanently joined to component leads. Each individual wire or wire grouping shall be accessible for replacement in the event of some unplanned damage during harness fabrication. If potting or molding is utilized to isolate, to insulate, or to provide strain relief (slug or mold); encapsulation shall be in accordance with SAE AS50881 paragraph 3.14.8.

## **3.8 Harness Identification and Data Requirements**

### **3.8.1 Wiring Data**

The preparation of wiring data shall be in accordance with MIL-HDBK-863 or an equivalent contractor format.

### **3.8.2 Identification of Individual Conductors**

The physical marking of individual conductors is required only to the extent needed to facilitate assembly, inspection, and possible modification of the wiring harness. Although it exceeds this requirement, physical marking of individual conductors or cables or cables may be accomplished in accordance with SAE AS50881 paragraph 3.9.

### **3.8.3 Identification of Harnesses**

To facilitate installation on the vehicle, and servicing in the field prior to launch, each wiring harness or cable assembly and each conductor shall be physically marked with its reference designation established in accordance with IEEE 200. Each wiring harness or cable assembly shall also be identified and physically marked with the drawing part number and a unique serial number at the time of fabrication. Each connector shall also carry the reference designation of its mating connector. The method and location of the physical identification shall assure legibility when installed in the vehicle and shall not impair the functional characteristics of the wire harness or cable assembly.

## **3.9 Operability**

### **3.9.1 Reliability**

The reliability design requirements shall assure that the overall vehicle reliability requirements are met under the most severe extremes of acceptance testing, storage, transportation, preflight testing, and operational environments.

### **3.9.2 Interchangeability**

Any two or more wiring harnesses or cable assemblies bearing the same part number shall possess such functional and physical characteristics as to be equivalent in performance and durability and shall be capable of being changed, one for another, without alteration of the items themselves or of adjoining items.

### **3.9.3 Maintainability**

The wiring harnesses shall be designed so as not to require scheduled maintenance or repair during their service life.

### **3.9.4 Service Life**

The service life of the wiring harnesses shall be specified as one year in addition to the service life of the vehicle for which it has been designed.

### **3.9.5 Environment**

The wiring harnesses shall be capable of meeting the functional characteristics and design requirements specified herein before and after exposure to preflight environmental conditions, and during all flight environmental conditions as specified in the vehicle type or detail specification.

### **3.9.6 Storage and Transportability**

It is preferred practice that complete wire harnesses not be removed from their three-dimensional forming boards until all quality assurance requirements have been met. The wiring harness should have dust caps installed on all connectors and then be moved from the fabrication forming board directly to installation on the vehicle without intermediate storage to avoid unnecessary handling. Whenever production schedules, alternate practices, or other considerations, require harness storage, the wire harness shall be packaged, handled, and transported in a manner that minimizes possible damage or environmental degradation. When a wiring harness is removed from the fabrication board for storage, dust caps shall be installed on all connectors and the entire harness placed in a protective bag or box. Unsupported handling shall be avoided. When a harness has been in storage for longer than 6 months, the quality assurance requirements shall be verified by test or retest immediately prior to the harness installation on the space vehicle.

### **3.9.7 Workmanship.**

All details of workmanship concerned with the fabrication and installation of wiring harnesses shall be controlled such that the finished item is of sufficient quality to ensure proper operation, safety, reliability, and service life.



## **4. Quality Assurance Requirements**

### **4.1 Responsibility for Inspections and Tests**

Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspections and test requirements as specified herein. The contractor may use their own facility, or any other facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the Government, except as otherwise specified in the contract. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

### **4.2 Classification of Inspections and Tests**

The tests and inspections specified herein are classified as follows:

- a. Parts, materials, and process controls (4.3)
- b. Physical configuration audit (4.4)
- c. Acceptance tests (4.5)
- d. Qualification tests (4.6)

### **4.3 Parts, Materials, and Process Controls**

To ensure that reliable wiring harness assemblies are fabricated, all parts and materials shall be adequately controlled and inspected prior to assembly. During fabrication, the tools and processes as well as the parts and materials, shall be adequately controlled and inspected. Each wiring harness assembly shall have inspection records and test records maintained by serial number to provide traceability. Complete records shall be maintained and be available for review during the service life of the wiring harness. The records shall document all relevant test data, all rework or modifications, and all installations or removals for whatever reason. The records shall include such items as crimp tool pull test data and mechanical stripper test data made at the beginning and end of each working day.

### **4.4 Physical Configuration Audit**

The first complete vehicle assembly shall be made available for inspection of the wiring harnesses as installed. There shall be no discrepancies among the installed wiring harness, the fabrication tooling used, the vehicle mockup, the released drawings, the test data, and the specification requirements.

### **4.5 Acceptance testing**

The configuration and workmanship of the completed hardware shall be verified by inspection prior to the start of acceptance testing. Each wiring harness delivered for acceptance shall have received, as a minimum, the following tests in the order listed in the following subparagraphs.

#### **4.5.1 Contact Retention Test**

Each rear insertable removable crimp contact (pin or socket) of the harness connectors shall be subjected to a retention push test, following insertion of contact in the connector insert. The force

shall be applied at the mating face of the connector to check the retention of the contact in the insert by the retention mechanism. The contact shall be retained when the applied force is 21 newtons.

#### **4.5.2 Circuit Resistance Test**

The continuity of each conductor and of each shield in the assembled wiring harness shall be determined by measuring the circuit resistance. This measurement shall be made using direct current with a voltage not exceeding 50 V and a current not exceeding 2 A. The measured resistance of each circuit shall be compared to its calculated value, but shall not exceed 0.5 ohms, except when the length of the conductor is such that its calculated resistance exceeds 0.3 ohms. The calculated resistance shall always be rounded to the next highest tenth ohm. For a calculated resistance between 0.3 ohms and 0.9 ohms, a test tolerance of 0.2 ohms shall be added to determine the maximum measured value allowed. For a calculated resistance value above 0.9 ohms, a test tolerance of 1>0 ohm shall be added to determine the maximum value allowed. The calculated resistance of shields shall be based on actual shield resistance values but shall not exceed 0.31 ohms per meter.

#### **4.5.3 Insulation Resistance Test**

This test shall be performed at a minimum DC potential of 500 V or at two times the peak voltage, whichever is greater. The insulation resistance shall be measured between each conductor and every other conductor, between each conductor and every conductor shield, and between each conductor and connector shell. The test potential shall be applied for 5 seconds and the measured resistance shall be greater than 10 megohms. A lesser test time may be used if the measured insulation resistance exceeds 10 megohms immediately following application of the test voltage, and continues to rise. For thermocouple instrumentation wiring, an insulation resistance of 1 megohm is acceptable.

#### **4.5.4 High Potential Withstanding Test**

This test shall be performed using either a 60 Hz AC potential or a DC test potential. Because the wiring capacitance results in higher AC currents that may give an erroneous indication of breakdown, only the DC test is recommended for cables longer than 3 meters. Coaxial cables and thermocouple instrumentation wiring are excluded from these high potentials withstanding test requirements.

##### **4.5.4.1 For 60 Hz AC Tests**

When a 60 Hz AC test potential is used, the test shall be performed at a potential of 1000 V plus twice the maximum working voltage of the harness or at 1500 V, whichever is the greater, or at the test potential specified by the connector manufacturer(s) for the connections in which the harness is terminated, if less than either of the previous. The test potential shall be applied for at least 5 seconds at a rate of no less than 500 V per second until the desired test potential is reached. The test potential shall be applied between each conductor and every other conductor, between each conductor and every conductor shield, and between each conductor and connector shell. There shall be no electrical breakdown or arc-over.

##### **4.5.4.2 For DC Test**

When a DC test potential is used, the test shall be protested in the same manner as described for AC test except that the DC potential used shall be not less than 1.4 times the appropriate AC test potential. For the DC test, the time of application of the test potential may be reduced to the time required for steady state current to be established. There shall be no electrical breakdown or arc-over. If a DC test potential is used for the high potential withstanding test, the insulation resistance required by 4.5.3 may be measured simultaneously.

#### 4.5.5 Insulation Resistance Retest

The insulating resistance test of 4.5.3 above shall be repeated to determine any damage caused by the high potential withstanding test, unless the insulation resistance test and high potential withstanding test are conducted simultaneously. The measured resistance shall be not less than 10 megohms.

#### 4.5.6 Contact Separation Force Test

Each socket contact of the harness connectors shall be subjected to a contact separation test to check the minimum separation force exerted on a hardened and polished steel test pin. The applicable test pin shall be inserted to fully bottom in each socket and the force required to remove the pin shall then be measured. The applicable test pin diameters, and the minimum separation forces, shall be as shown in Table 2. For contact sizes not shown in Table 2, an appropriate test pin diameter and minimum separating force shall be used.

#### 4.5.7 Environmental Testing

Thermal vacuum, vibration, shock, and electromagnetic interference test requirements of wiring harnesses and cable assemblies may be performed in conjunction with the vehicle level tests.

Table 2. Contact Separating Forces Requirements

MATING END SIZE (AWG)	SEPARTING TEST PIN DIAMETER (millimeters)	MINIMUM SEPARATION FORCE (newtons)
22	0.737 + 0.000 - 0.005	0.139
20	0.991 + 0.000 - 0.005	0.139
16	1.562 + 0.000 - 0.005	0.370
12	2.362 + 0.000 - 0.005	0.556
10	3.150 + 0.000 - 0.005	0.648
<u>8</u>	3.581 + 0.000 - 0.005	0.741

#### 4.5.8 Acceptance Criteria

The acceptance criteria for wiring harnesses is the satisfactory completion of all contractually imposed acceptance tests. If a test discrepancy occurs during an acceptance test, the test shall be interrupted and the discrepancy verified. The disposition of the discrepancy should be completed before the testing resumes. If the discrepancy is dispositioned as due only to the test setup, test cables, or to a failure in the test equipment, the test being conducted at the time of the failure may be continued after the repairs are completed, as long as the discrepancy did not result in an overstress test condition. If an overstress test condition occurred or if the discrepancy is dispositioned as a failure in the wiring harness under test, the preliminary failure analysis and appropriate corrective action shall be completed in accordance with the established procedures for handling nonconforming supplies. The acceptance test in which the failure occurred, and any previous test whose results could possibly have induced the failure, or whose validity was comprised by the corrective action, would then be entirely repeated.

#### **4.6 Qualification**

Wiring harness qualification may be partially or totally satisfied by qualification of higher levels of assembly that include the harness. Qualification tests shall be conducted to approve test plans that indicate what tests and test procedures will be conducted at what levels of assembly. Applications having constraints on allowable outgassing shall qualify to that requirement either by test, or by an analysis using applicable materials test data to determine the estimated total mass loss and the estimated loss of volatile condensable materials for each wiring harness during its service life. Applications of harnesses that cross moving or rotating interfaces shall include harness stiffness measurements and fatigue testing that may be appropriate. These tests and measurements shall be conducted under the case dimensional conditions, with maximum motion, at ambient conditions as well as under worst case design environmental conditions.

#### **4.7 Modifications, Rework, and Retesting**

Completed wiring harnesses shall be modified and reworked with the same high quality assurance provisions and criteria as an original harness. Unless specifically limited by the approved change proposal, the inspection and retesting requirements following modification shall not be limited to the changes or modifications, but the complete harness must be retested including the changes. Inspection and retesting requirements following rework shall be consistent with the type and extent of the rework, location where the rework is accomplished, and the inspection and testing criteria for the original harness.



## **5. Packaging (Not Applicable)**



## 6. Notes

### 6.1 Tailored Application

This specification is intended for use in equipment specifications or contracts to incorporate those requirements which are common to most space vehicle wiring harnesses. The requirements stated in the specification are a composite of those that have been found to be cost effective for high reliability space vehicle applications. This document establishes the minimum requirements for most space vehicle applications. Where possible, the requirements are stated in ways that are self-tailored to each application. For example, the EMP requirements are not imposed by this specification unless an EMP environment is indicated by some other compliance document. Nevertheless, all requirements of this specification should be evaluated for each application and those that are not appropriate, or clearly increase program life cycle costs, should be excluded or changed. Contractors are encouraged to identify to the contracting officer, for program office review and reconsideration, any requirements imposed by this document that are believed to be excessive. However, contractors are reminded that deviations from contractually imposed requirements can be granted only by the contracting officer. Tailoring of shielding requirements should be based upon electromagnetic compatibility analysis or tests for particular applications. Because of the similarity of requirements, this specification may be used to specify requirements for interconnecting wiring on launch vehicles, intercontinental ballistic missiles, reentry vehicles, and other vehicles. For those applications the term “space vehicle” is to be interpreted as the applicable vehicle. All wiring which is completely internal to electrical or electronic equipment should be in accordance with the applicable equipment specifications rather than this document. For clarification, the terms “aerospace vehicle” or “aircraft” in SAE AS50881 are to be interpreted as including space vehicles or other applicable vehicles.

### 6.2 Definitions

#### 6.2.1 Wire

A single metallic conductor of solid or stranded construction designed to carry current in an electric circuit, but which does not have a metallic covering, sheath, or shield. For this specification, “wire” refers to “insulated electric wire.”

#### 6.2.2 Shield

A metallic sheath surrounding one or more wires, cable assemblies, or a combination of wires and cables that is used to prevent or reduce the transmission of electromagnetic energy to or from the enclosed conductors.

#### 6.2.3 Cable

Two or more insulated conductors, solid or stranded, of equal length, contained in a common covering; or two or more insulated conductors, of equal length, twisted together without common covering; or one insulated conductor with a metallic shield or outer conductor (shielded wire or coaxial cable).

#### 6.2.4 Cable Assembly

A cable with all conductors and shields insulated and terminated to connectors, terminal lugs, or other suitable devices.

### **6.2.5 Wiring Harness**

A group of wires, shields, cables, or cable assemblies, or any combination of these, all insulated and properly terminated to connectors, terminal lugs, or other suitable devices and mechanically held together by ties, straps, clamps, insulating jacket, or other means so that it can be installed as a single unit for the interconnection of two or more electrical or electronic equipments. A cable that is a complete unit ready for installation in a vehicle is considered a wiring harness.

### **6.3 Supersession Data**

This issue is a complete revision that supersedes the previous issue of MIL-W-83575 for new designs. The previous issue of MIL-W-83575 remains in effect to cover the procurement of previously designed equipment.

## SMC Standard Improvement Proposal

### INSTRUCTIONS

1. Complete blocks 1 through 7. All blocks must be completed.
2. Send to the Preparing Activity specified in block 8.

NOTE: Do not be used to request copies of documents, or to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Comments submitted on this form do not constitute a commitment by the Preparing Activity to implement the suggestion; the Preparing Authority will coordinate a review of the comment and provide disposition to the comment submitter specified in Block 6.

<b>SMC STANDARD CHANGE RECOMMENDATION:</b>	<b>1. Document Number</b>	<b>2. Document Date</b>
<b>3. Document Title</b>		
<b>4. Nature of Change</b> (Identify paragraph number; include proposed revision language and supporting data. Attach extra sheets as needed.)		
<b>5. Reason for Recommendation</b>		
<b>6. Submitter Information</b>		
<b>a. Name</b>	<b>b. Organization</b>	
<b>c. Address</b>	<b>d. Telephone</b>	
<b>e. E-mail address</b>	<b>7. Date Submitted</b>	
<b>8. Preparing Activity</b>	Space and Missile Systems Center AIR FORCE SPACE COMMAND 483 N. Aviation Blvd. El Segundo, CA 91245 Attention: SMC/EAE	